LYSINE

1. Introduction

L-Lysine is one of the essential amino acids, which cannot be synthesized in the body. The main application of Lysine is animal feed. The global market for food-grade L-Lysine is estimated at over 800,000 ton (2007 figure). The market price for bulk Lysine has dropped significantly over the past decade(s), forcing suppliers to apply more efficient manufacturing technologies.

L-Lysine is produced by fermentation of Brevibacterium flavum, which yields very high concentrations of Lysine in the broth. Other strains have been developed, e.g. to produce lysine based on other substrate for instance bio-based materials.
After the fermentation, the Lysine broth is clarified and subjected to ion exchange for purification, followed by concentration and crystallization. The mother liquor of the crystallization is recycled towards the ion exchange system.

This study also applies to other amino-acids. Amino-acids typically are zwitter-ions, the amino group can be protonated ($-C-NH_3^+$) at a certain pH and the carboxylic acid is then deprotonated (COO^-). This means they can bind to either (strong) cation and/or anion resins, depending on pH related to their iso-electric point(s) (IEP).
Not all amino-acids show a straight-forward ionic behavior due to the complexity of their side-chain, for example tryptophan contains indole, creating a non-polar, aromatic amino-acid.

2. Typical Process Conditions

The most relevant specifications for a typical Lysine feed solution (combined fermentation broth and recycled crystallization mother liquor) are:

Lysine content	150 kg/m^3
Density	1060 kg/m^3
Viscosity	2.0 cP
Temperature	40℃ (design temperature 50 ℃)

Generally, the mother liquor represents approximately 15% of the overall lysine content in the ion exchange system.

3. Process Design

The key parameters in the process design for 50 ktpa production capacity are:

System sizing	
SMB carousel model	30 – 75 (30 columns and (distributor) valve port size 75 mm internal diameter)
Specific productivity	300 tpa/m^3
Resin volume for a 50 ktpa capacity	165 m^3
Consumption of water and chemicals	
Total water consumption	146 m^3/h
	3513 m^3/day
	24.6 m^3/tonne Lysine
Net water consumption	65.5 m^3/h
	1572 m^3/day
	11.0 m^3/tonne Lysine
Ammonia consumption	7.18 m^3/h
	0.274 kg dry NH_3/kg Lysine

The net water consumption takes into account the fact that the entrainment rejection water (3.63 m³/h) is recycled in the process.

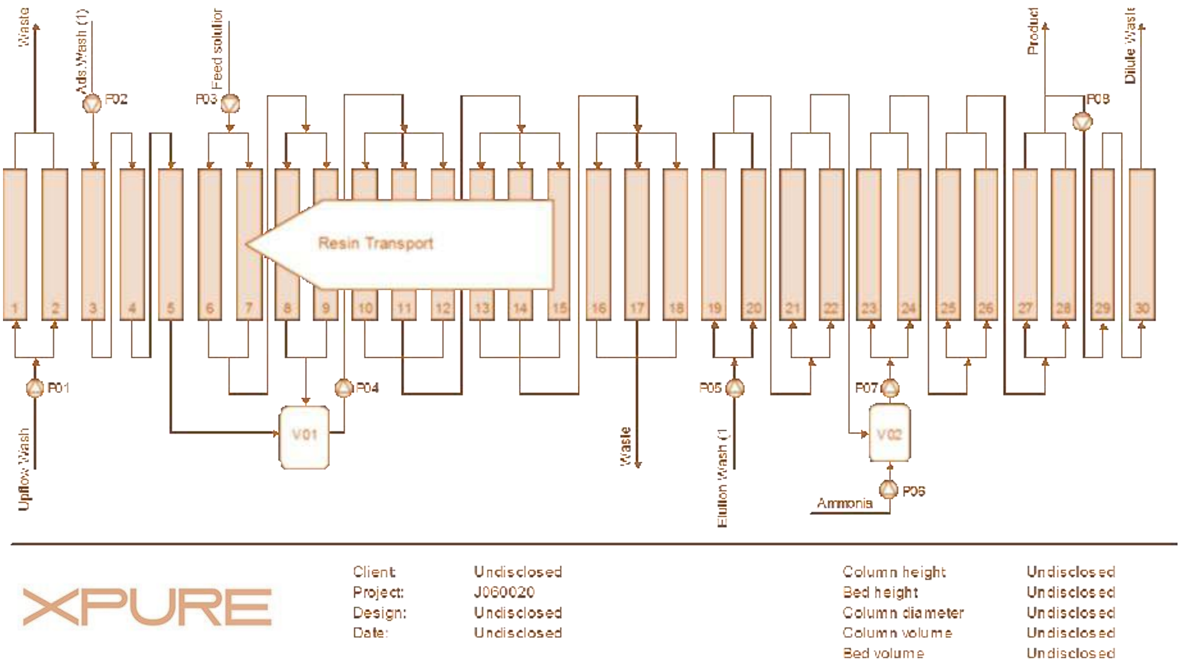

Figure 1. Simplified Process Flow Diagram for the purification of lysine using 30 columns .

More than 75% of world production of Lysine is purified using continuous ion exchange. For the purification of Lysine, nowadays, normally carousel type systems with 30 columns are used. An example PFD is given in figure 1. This configuration comprises the following zones:

- Upflow wash: This allows removal of any undissolved particulates from the resin bed, for example originating from the broth, by slightly expanding the resin bed
- Adsorption wash: washing the interstitial fluid from the resin beds after the adsorption.
- Undiluted Adsorption: In the design presented above, the Lysine is applied on these columns as monovalent cation (Ly^{+}), in order to optimize the effective loading capacity on the resin.
- Diluted Adsorption: the remaining Lysine is adsorbed as divalent cation (Ly^{2+}). Prior to being applied to these columns, the effluent of the first loading zone (columns 6 – 9) is diluted with the wash water (effluent of column 5) and acidified with sulfuric acid. In order to limit the fluctuations in concentration and pH (not shown).
- The elution rinse: to prevent carry-over of ammonia into the adsorption zone.
- The elution in order to produce a highly concentrated Lysine product with minimum amount of ammonia, the excess ammonia flux is limited to 15 – 20%. Prior to being applied on the column, the ammonia is diluted with the elution rinse water

- Entrainment rejection zone is included. In this column, the interstitial wash water that comes from the upflow wash (columns 1 and 2) is displaced by product to such extent that no product loss occurs. Depending on the quality of the effluent from column 30, this water can be recycled

3.1 Alternative SMB configurations with less columns

The purification can also be done in a carousel type of system with 20 columns, configured similarly to the 30 column system. The number of columns in the different zones is reduced which will have some influence on the performance of the Lysine purification. Further a 20 column system would offer less flexibility applying for example an additional upflow wash and entrainment rejection zone. The latter is useful to increase product concentration in the effluent. Both configurations are possible on a carousel type of SMB but are too complex on a static SMB. Static type systems normally uses a lower number of columns. Often only 8 or 12 columns are used meaning even less flexibility remains for additional zones. A fundamental consequence of a 8-12 column system is a strong decrease of the counter current effect in wash and multipass adsorption zones.
In Table 1 the effect of the SMB configuration on the resin inventory has been illustrated. It is obvious that the related wash and rinse volumes will inverse proportionally grow with the installed resin volume.

Table 1. Comparison study between 30, 20 and 12 column SMB system (basis 15 m^3/h feed flow @ 150 kg Lysine/m^3)

Configuration	Resin volume/column	Total resin volume
30 columns	1.3 m^3	**39 m^3**
20 columns	2.4 m^3	**48 m^3**
12 columns	4.7 m^3	**56 m^3**

4. Conclusion

A carousel configured SMB system, comprising 30 resin columns, offers a very efficient and robust process for the purification of L-Lysine from a fermentation broth. The system offers enormous flexibility, allowing minimization of the consumption of water and chemicals.
A SMB system with less columns, for example 20 or even 12 columns, will give reason to compromise flexibility and effective resin utilization to maintain the same performance.
The static type of continuous IX –e.g. 8-12 columns- is more complex in terms of fluid distribution valve blocks than the carousel type of continuous IX.
Although the static type of continuous IX uses less columns, the column volume needs to be substantial larger to obtain the same adsorption efficiency. The total resin volume will therefore be larger than in a carousel system. The reduction of columns also reduces the wash efficiency, the purity and concentration of the product and it reduces the total yield of the process